

# Image-to-Mesh Conversion Tool

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## Motivation

Motivating application: to provide an easy-to-use Image-To-Mesh Conversion tool (I2MTool) for medical imaging computing. Certain problems like deep brain tumors are very challenging to handle with existing algorithms and we will adopt semi-automatic/interactive ways to approach them.

## Approach

- 1) Implement several modules essential to medical imaging, more specifically:
  - a. **Image-To-Mesh (I2M) Conversion: Delaunay-based, Lattice De-refinement [1], Body-Centered Cubic Lattice Refinement & Deformation (CBC3D)**
  - b. **Registration: Affine Registration, B-Spline Registration, Point-Based Registration, Point-Based Warping, Physics-Based Non-Rigid Registration**
  - c. **Miscellaneous Tools: Interactive and Hausdorff Distance Measuring, Volume Fraction Measuring, Region Grow Segmentation, and Image Resampling.**
- 2) Use some existing algorithms implemented within the ITK library [2].

Methods for two recently implemented modules:

Physics-Based Non-Rigid Registration [3]: This module registers a moving to a fixed MRI. It uses a linear homogeneous bio-mechanical model to compute a dense deformation field that defines a transformation for every point in the fixed image to the moving image.

CBC3D [4]: This module generates an adaptive multi-tissue tetrahedral mesh from a multi-label segmented image. Initially, this module constructs an adaptive Body-Centered Cubic (BCC) mesh of high quality elements. Then, it deforms the mesh surfaces to their corresponding physical image boundaries, hence, improving the mesh fidelity and smoothness. The deformation scheme, relies on a multi-material point-based registration, and performs between a source and a target point-set. The first set contains the surface/interface vertices of the mesh. The second set contains the surface/interface voxels of the object depicted in the image. The mesh deformation performs a number of iterations specified by the user. The larger the number of iterations, the higher the mesh fidelity and the smoother the mesh surface.

## Implementation

A class for each module within the I2MTool

**CBC3D, MultipleSurfaceMeshesGeneration, MeshGenerationRefinement, AffineRegistration, BSplineRegistration, PointBasedRegistration, PointBasedWarping, PhysicsBasedNonRigidRegistration, HausdorffDistance, VolumeFraction, RegionGrow, ImageResampling**

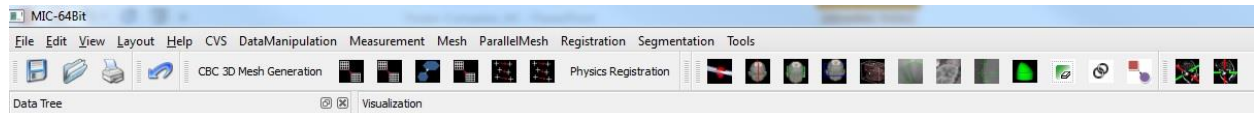


Figure 1: The GUI of the I2MTool allows for saving images/meshes, loading them, printing them, using all of the listed modules, and using several visualization tools (such as showing the X, Y, Z and box widgets, seed setting, and showing an orthogonal/oblique view of a mesh)

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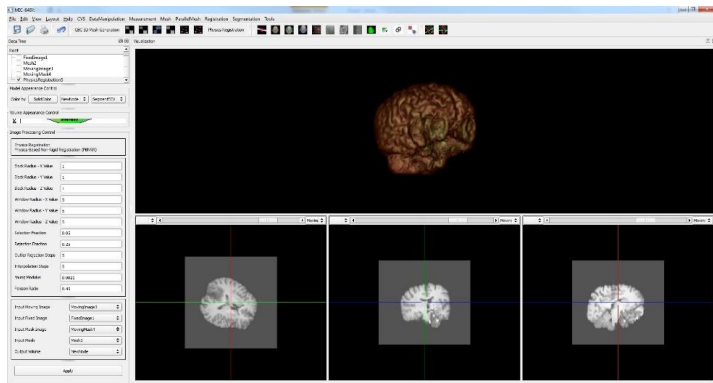


Figure 2: Use of the Physics-based Non-Rigid Registration method within the I2MTool, the GUI for this particular module can be seen on the left, the bottom 3 visualization panels allow for any image to be shown, and the top panel shows the newly registered image volume

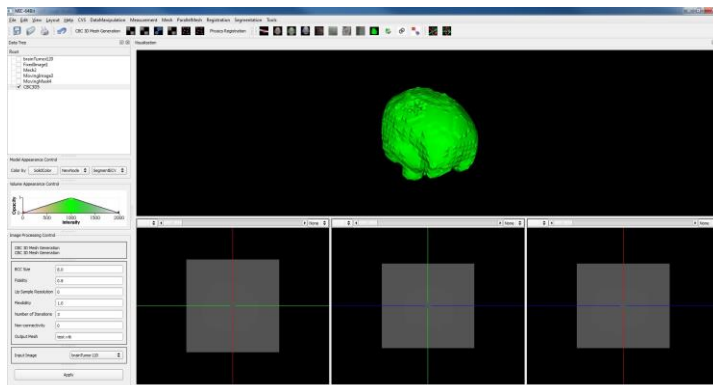


Figure 3: Use of the CBC3D method within the I2MTool, the GUI for this particular module can be seen on the left with the top panel showing the deformed mesh that this module generates

## Future Work

This tool contains some of the functionality in well known medical imaging software tools such as 3D Slicer and Paraview, but will also support additional features not seen in any medical imaging tool to date. One feature in particular that will be implemented is the ability to edit a mesh directly from the GUI of the I2MTool. Another method that will be implemented is the ability to select an area of a mesh and generate a new detailed mesh of the selected area of the original mesh.

Although the CBC3D module generates multi-material meshes, the current version of the I2MTool cannot distinguish among tissues using different colors when displaying meshes. It can only display a mesh with one solid color for the entire mesh. The module is still able to use and generate multi-tissue meshes, which could be viewed in multiple colors in other tools such as Paraview. The ability to display a multi-tissue labeled mesh using different colors will be implemented in the future. The ability to cut a mesh to get a cross-section and view the inside of it will also be implemented.

## References

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- [4] Drakopoulos, F., Ortiz, R., Enquobahrie, A., Sasaki-Adams, D., & Chrisochoides, N. (2015). Tetrahedral image-to-mesh conversion software for anatomic modeling of arteriovenous malformations. 24th International Meshing Roundtable, TX.

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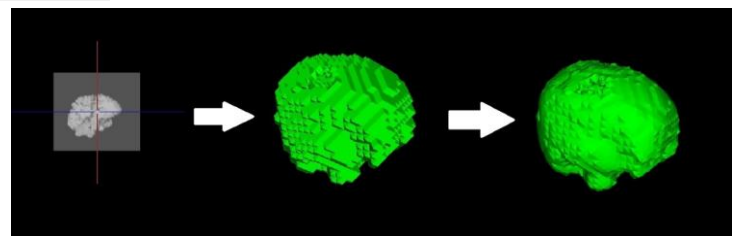


Figure 4: A multi-label segmented image is shown on the left. The BCC tetrahedral mesh that the CBC3D method in the I2MTool generates from it is shown in the middle and the final, deformed mesh is shown on the right.